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IS 13360-7-1 (1996): Plastics - Methods of Testing, Part 7: Electrical Properties, Section 1: Measurement of Resistivity of Conductive Plastics [PCD 12: Plastics]

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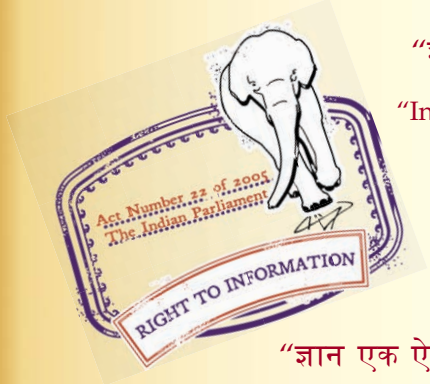

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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IS 13360 (Part 7/Sec 1) : 1996
ISO 3915 : 1981

(Reaffirmed 2003)

भारतीय मानक

प्लास्टिक सामग्रियाँ — परीक्षण पद्धतियाँ

भाग 7 विद्युतीय गुणधर्म

अनुभाग 1 चालक प्लास्टिक सामग्रियों का प्रतिरोध मापन

Indian Standard

PLASTICS — METHODS OF TESTING

PART 7 ELECTRICAL PROPERTIES

Section 1 Measurement of Resistivity of Conductive Plastics

ICS 83.080

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

August 1996

Price Group 2

NATIONAL FOREWORD

This Indian Standard which is identical with ISO 3915 : 1981 'Plastics — Measurement of resistivity of conductive plastics' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of Methods of Test for Plastics Sectional Committee and approval of the Petroleum, Coal and Related Products Division Council.

The text of ISO standard has been approved as suitable for publication as Indian Standard without deviations, Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard', and

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In reporting the results of a test or analysis in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

PLASTICS — METHODS OF TESTING

PART 7 ELECTRICAL PROPERTIES

Section 1 Measurement of Resistivity of Conductive Plastics

0 Introduction

The method specified in this International Standard is technically similar to that specified for rubber in ISO 1853, *Conducting and antistatic rubbers — Measurement of resistivity.*

However, it differs from that method in certain details, especially those associated with the greater stiffness of the plastic samples, and in particular in the limitation on specimen width. It takes into account two problems encountered in the measurement of resistivity of conductive plastics, namely the sensitivity of these materials to their temperature-history and strain-history, and the difficulty of making adequate electrical contact with them.

The prescribed width of the specimen is mandatory for reference purposes; however, a wider strip may be used, with correspondingly wider electrodes. There is a danger in using a wide strip, if the strip is slightly twisted and at the same time somewhat non-uniform in its resistivity. It is then possible to obtain erroneous results; the potential electrode nearer to the positive current electrode may even be found to be negative with respect to the other potential electrode.

Effect of temperature changes and strain on conductive plastics

As mentioned above, the resistance of these materials is sensitive to their temperature-history and strain-history. The relationships are complex and arise from the kinetic energy and structural configuration of the carbon particles in the polymer.

The resistivity may be increased by the effects of strain produced by (or subsequent to) removal from the mould, and a treatment is described for reducing specimens to a constant strain and temperature condition before measurements are carried out on them. Specimens are also cut in two perpendicular directions to assess anisotropy.

Electrode systems (see 3.3)

Certain types of electrode, when applied to these polymers, have a contact resistance which may be many thousand times greater than the intrinsic resistance of the specimen. Dry contacts under light pressure or point contacts give very high resistances. However, the present test method eliminates the effects of contact resistances unless these are excessively high. (In such a case, no result, rather than a wrong one, is generally obtained.)

1 Scope and field of application

This International Standard specifies the requirements for the laboratory testing of the resistivity of specially prepared specimens of plastics rendered conductive by the inclusion of carbon black. The test is suitable for materials of resistivity less than 10^6 Ω·cm (10^4 Ω·m). The result is not strictly a volume resistivity, because of surface conduction, but the effects of the latter are generally negligible.

The principle of the four-terminal method of test is mandatory and the recommended specimen size and electrode design must be adhered to for reference purposes, but it may sometimes be necessary to test a wider strip with electrodes of a different construction.

2 Principle

A stable d.c. current of magnitude (I) is passed between electrodes at the two ends of a strip of the material under test. The voltage drop (ΔU) between two potential electrodes is measured with an electrometer. The resistance of the portion of the strip between the potential electrodes is given by $R = \Delta U/I$, and is independent of contact resistances. Thus the resistivity may be calculated.

3 Apparatus (see figure 1 for schematic diagram of test circuit)

3.1 Current source : a source of direct current which has a minimum resistance to earth of 10^{12} Ω (effected by placing it on a highly insulating sheet), and which will not cause a dissipation of power greater than 0,1 W in the specimen.

3.2. Milliammeter or **microammeter**, as appropriate, for measuring the current to an accuracy of ± 5 %.

NOTE — Small currents may be computed from measurement of the voltage drop across a known resistance in series with the specimen, using the electrometer (3.4)

3.3 Electrodes

3.3.1 Current electrodes, of clean metal, together with either suitable clamps or grips approximately 5 mm long and extending across the full width of the specimen, or **conductive paint** to cover the same area.

3.3.2 Potentiometric electrode system (see figure 2, for example), having a mass of approximately 60 g so that it exerts a force of approximately 0,6 N on the specimen. The contacts shall normally be 10 ± 0,2 mm apart. For special purposes, the contacts may be further apart (up to 70 mm), but the separation shall be less than the specimen length by at least 60 mm. The distance between the contacts shall be known to an accuracy of ± 2 %. The insulation resistance between the contacts shall be at least 10^{12} Ω.

3.4 Electrometer, having an input resistance greater than 10^{11} Ω and measuring to an accuracy of ± 5 %.

3.5 Sheet of highly insulating material, having a volume resistivity greater than 10^{15} Ω·cm.

3.6 Oven, capable of being maintained at a temperature of 70 ± 2 °C.

4 Specimen

The specimen shall be a strip 10 mm wide and 70 to 150 mm long and shall normally be 3 to 4 mm thick with a tolerance on uniformity of thickness of ± 5 %. Thicker or thinner specimens may be cut from sheets or products. Care shall be taken to avoid bending or stretching the sheets or specimens, especially when they are thinner than standard.

The specimen may be cut with a knife or razor blade, but care must be taken to minimize distortion as this will affect the resistance values.

The surfaces of the specimen shall be clean; if necessary, they may be cleaned by rubbing with fuller's earth (hydrated magnesium-aluminium silicate) and water, rinsing with distilled water and allowing to dry.[1] The surfaces shall neither be buffed nor abraded, nor shall they be cleaned with organic materials that attack or swell the material.

5 Number of specimens

From each of two perpendicular directions, three specimens of equal size shall be prepared and tested. The two directions should, where possible, be chosen to be along and across any direction of flow during processing.

6 Procedure

6.1 After preparation, allow the specimen to remain at room temperature and ambient humidity conditions for at least 16 h.

6.2 Prior to the commencement of the test, connect the current electrodes (3.3.1) to the ends of the specimen, either by using the clamps or grips, or by covering the same area with conductive paint.

6.3 The required conditioning of the specimen should be described in the material specification. If this is not the case, the following procedure will probably be useful in most cases : Immediately after applying the current electrodes, place the specimen on the sheet of highly insulating material (3.5) and heat in the oven (3.6) for 2 h at a temperature of 70 ± 2 °C to remove strains and irregularities caused by previous treatment. Cool for at least 1 h and test at 23 ± 2 °C and 50 ± 5 % relative humidity without disturbing the specimen. The specimen shall always be tested on the sheet of insulating material. With some materials, distortion may occur at 70 °C and heating for 5 h at 60 ± 2 °C may then be preferable.

6.4 Place the potentiometric electrode system (3.3.2) on the specimen, ensuring that the knife-edge contacts are at right angles to the direction of current flow and that neither potentiometric electrode is within 20 mm of a current electrode. Apply the current and measure the voltage drop between the potentiometric electrodes using the electrometer (3.4).

Repeat the measuring procedure twice more on the same specimen, moving the potentiometric electrodes each time to obtain measurements over lengths of specimen evenly distributed between the current electrodes.

6.5 Test the other five specimens similarly.

7 Expression of results

7.1 Calculate the resistance R, in ohms, corresponding to each position of the potentiometric electrodes, using the formula

$$R = \frac{\Delta U}{I}$$

where

ΔU is the voltage drop, in volts, between the potentiometric electrodes;

I is the current, in amperes, through the specimen.

7.2 The resistivity ϱ, expressed in ohm centimetres, is given by the formula

$$\varrho = \frac{R \times A}{d}$$

where

R is the resistance, in ohms, calculated in accordance with 7.1;

A is the cross-sectional area, in square centimetres, of a specimen perpendicular to the current flow (see figure 3);

1) If a particular drying method is necessary, it should be stated in the material specification.

d is the distance, in centimetres, between the potentiometric electrodes.

For each direction of current flow, determine the median of the nine resistivity values thus calculated.

8 Test report

The test report shall include the following particulars :

a) reference to this International Standard;

b) complete identification of the sample, including processing details if relevant;

c) dimensions of the test specimen;

d) conditioning, if different from that described in 6.3, or if the 60 °C conditioning is used;

e) the distance between the potentiometric electrodes;

f) the average value of voltage drop measured;

g) the individual resistivity values and the medians of the results in the two directions of test;

h) any other details that may have had an effect on the test results.

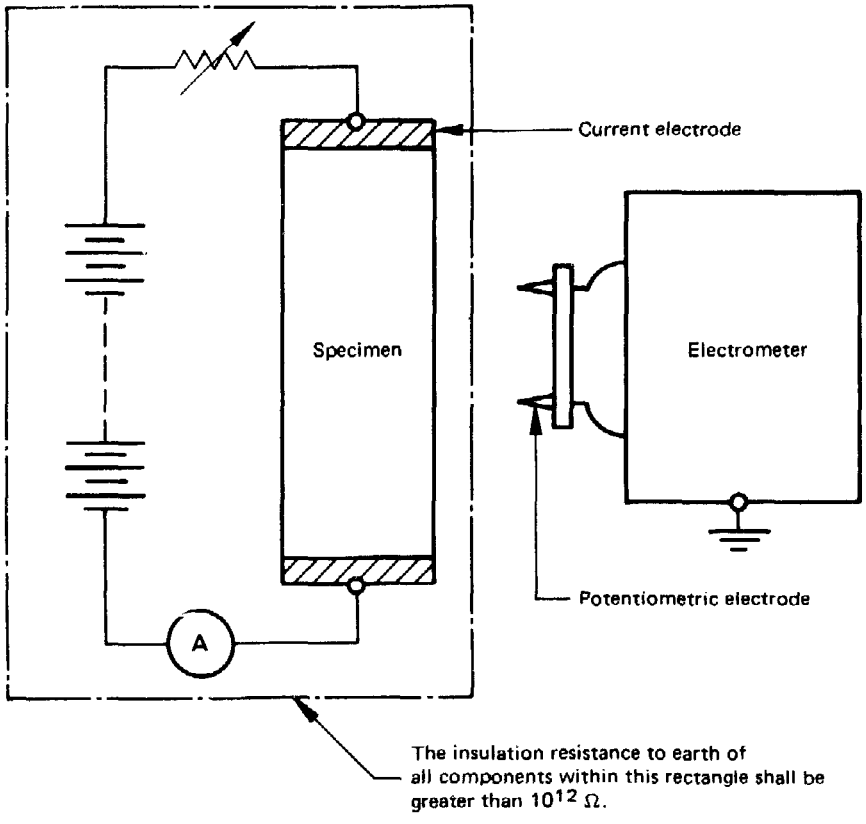

Figure 1 — Schematic diagram of test circuit

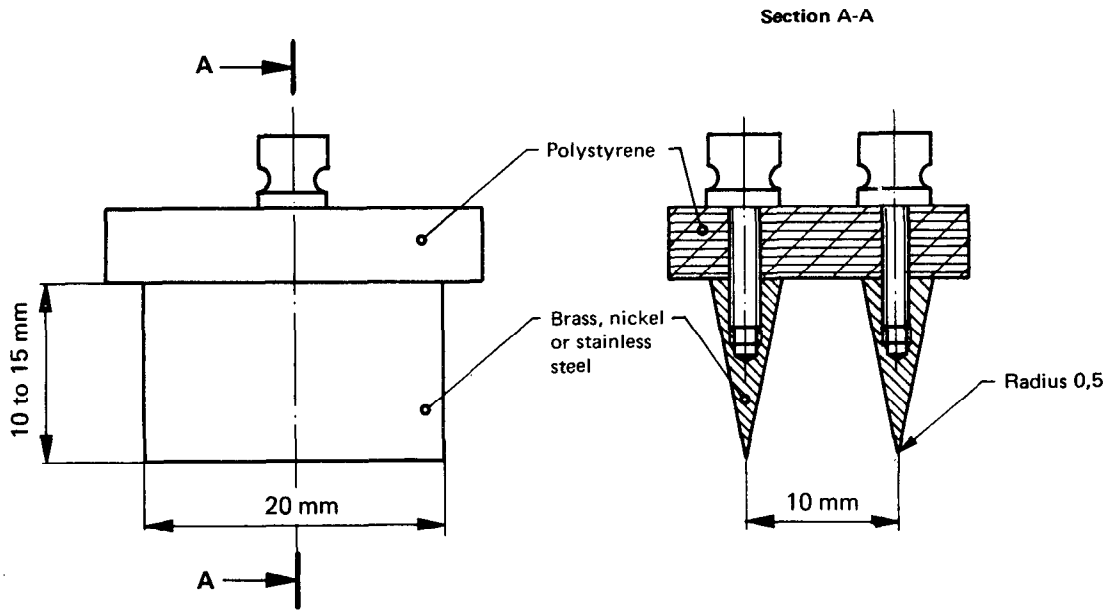

Figure 2 — Potentiometric electrodes

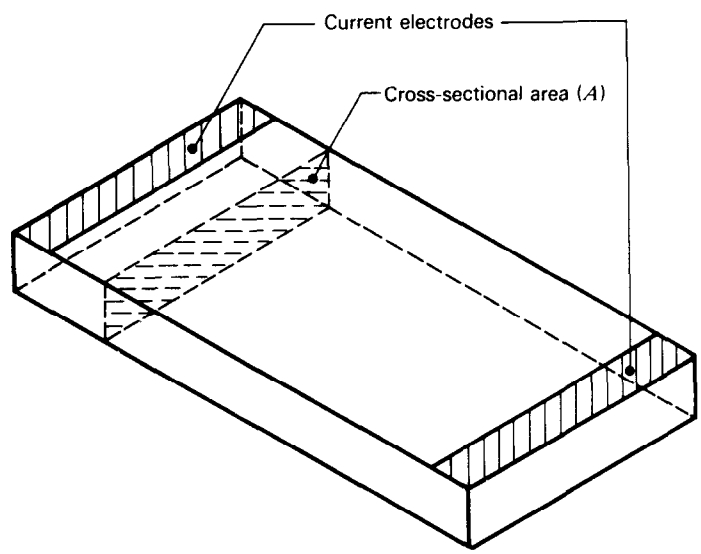

Figure 3 — Test specimen

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